Use of the Washington State WET Database To Demonstrate Inadequate Monitoring Frequencies and Cost-effectiveness

ABSTRACT

Key Words: WET testing, monitoring frequency, cost-effectiveness, rapid screening

Randall Marshall, WA State Dept. of Ecology, Olympia, WA. WET tests conducted for monitoring Washington State N.P.D.E.S. discharges are reviewed and entered into a database. The database now contains over 3,000 WET test results from 120 permittees. Acute WET is uncommon even in 100% effluent. About half of the short-term chronic tests show no toxicity in 100% effluent and over 80% of them show no toxicity at effluent concentrations of regulatory concern. Toxicity at levels of regulatory concern does occur occasionally for at least two thirds of permittees. An analysis of the WET test results suggests that monitoring frequencies are too low to adequately characterize episodic toxicity. We suggest that inexpensive toxicity tests conducted as screening tests at a higher monitoring frequency would be more cost-effective in detecting episodic toxicity.

INTRODUCTION

The national strategy [1] for assessing and regulating whole effluent toxicity (WET) is currently being re-evaluated. SETAC conducted the Pellston Workshop on whole effluent toxicity testing in September 1995 in order to resolve important scientific issues involving the regulatory application of WET testing. In September 1996, EPA hosted the WET Stakeholder's Meeting to get broader input in developing the Pellston Workshop recommendations into a new strategy for regulating WET [2]. The adequacy of common effluent monitoring frequencies for characterizing episodic toxicity as to duration and frequency of occurrence has not been discussed much. The cost-effectiveness of the current regulatory application of WET testing has not been assessed as a part of these discussions.

Industrial effluents can be highly variable within small time intervals. Bleckmann *et al* reported that the toxicity of an oil refinery effluent varied by more than a factor of 16 to the most sensitive of 5 species tested on 11 effluent samples collected within a 35-day sampling interval [3]. Reference toxicant (SDS) testing was used to measure the inherent variability of the toxicity tests within the lab, and this information was used to demonstrate that the toxicity of the effluent was much more variable than can be accounted for by test variability.

Sherry *et al* found that 8 samples within 4 months from 3 oil refineries (2 refineries sampled twice and the 3rd sampled 4 times) were inadequate to determine if apparent differences in toxicity between the refinery effluents were real or due to the temporal variability of the individual effluents [4].

Stormwater toxicity can be episodic and vary greatly from storm event to storm event. Fisher *et al* reported toxicity in storm water samples from 4 storm events at a site at an airport that ranged from completely nontoxic to an LC_{50} of 1.1% effluent [5].

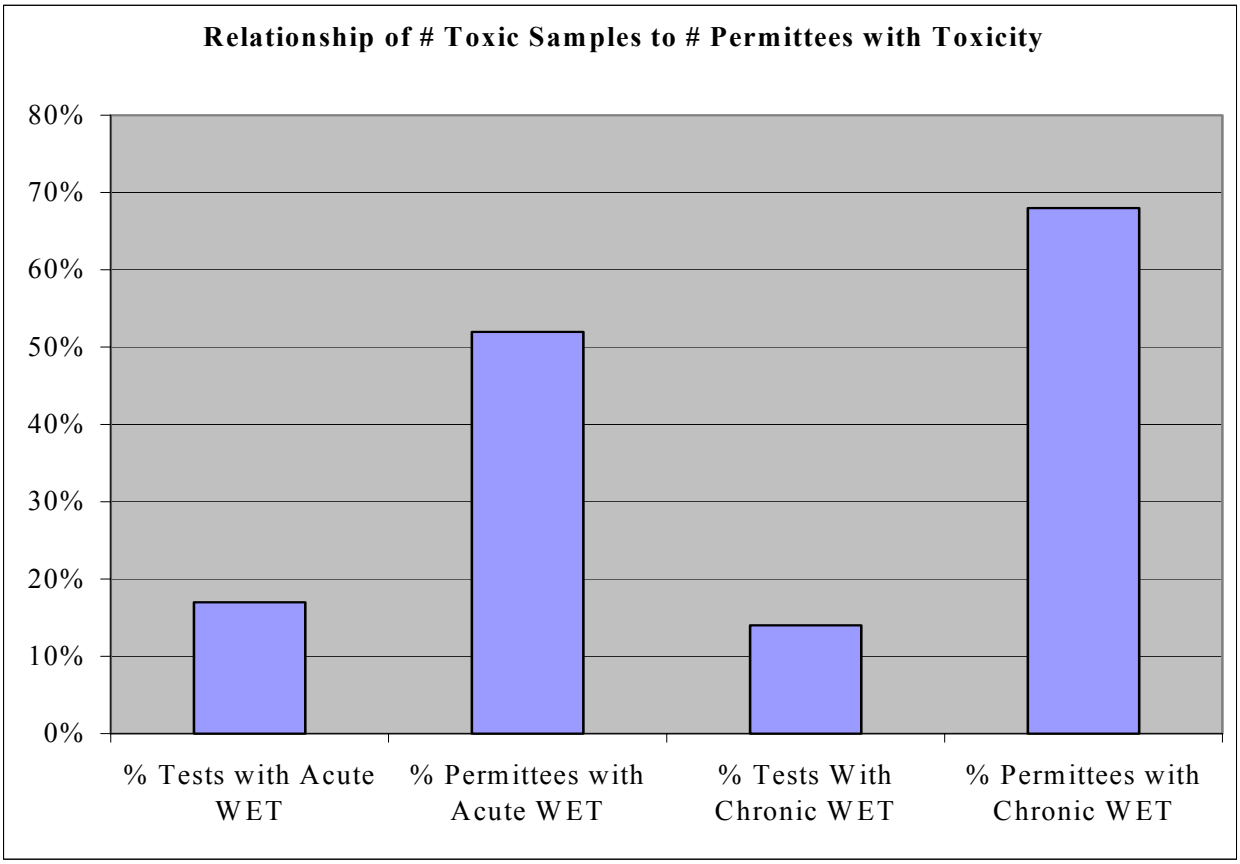
Episodic toxicity also occurs in ambient waters and may be the result of point source or nonpoint source discharges [6, 7, 8].

An important conclusion from examining the occurrence of acute and chronic toxicity in effluents in Washington State is that the technology-based permitting program was fairly successful in controlling toxicity. Treatment plants may not be designed to control toxicity, but they often do a very good job of removing toxicity anyway. The only problem is that these treatment plants are not consistent, and many produce episodes of toxicity.

Forty-seven percent of 1,853 acute tests had 100% survival in 100% effluent, and 72% had 90% survival or better in 100% effluent. Eighty-three percent of these tests met the state's acute toxicity performance standard of at least 65% survival in 100% effluent with a median percent survival of 80%. However, the 17% of acute tests which failed to meet the performance standard were distributed throughout 52% of permittees.

A fair number of chronic tests also show no toxicity at end-of-pipe. 59% of chronic NOECs were 100% effluent.

The bad news associated with our experience with WET test results is the wide distribution amongst permittees of those tests showing significant toxicity. Only 48% of permittees have never shown acute WET at levels of regulatory concern, and only 32% have never reported chronic WET test results at levels of regulatory concern. The 11% of chronic tests with toxicity of regulatory concern were distributed across 68% of the permittees in the database. These occasional excursions have unknown duration and pattern because of inadequate monitoring frequencies.



MATERIALS AND METHODS

The State of Washington's Department of Ecology has assembled the data and results from over 3,000 acute and chronic WET tests into a database. The results of 792 chronic tests conducted on samples from 53 NPDES permittees were evaluated for toxicity at concentrations of regulatory concern (IWC or instream waste concentration at edge of mixing zone during critical conditions). The total number of permittees with chronic WET test results in the database is 105, but only 53 have established mixing zones and IWCs. The results of this evaluation were used to determine the average cost for detection of one episode of regulatorily significant toxicity. The results were also used in a probability analysis to determine the sampling frequency necessary to have confidence in the characterization of a typical effluent's toxicity.

Five (5) of the accredited labs doing the most testing on effluents from Washington State were surveyed by telephone to determine an average cost for chronic tests. The 7-day fathead minnow and *Ceriodaphnia dubia* tests are 75% of the chronic tests in the database. The average cost for these tests is $1,200/test and was selected for use in the evaluation of the testing program because it represents 75% of the data and the costs of the less common chronic tests range about equally to both sides. Saltwater 7-day tests are slightly more expensive and all other chronic tests are slightly less expensive than $1,200. Single echinoderm fertilization tests are the least expensive chronic tests and can be as low as $600. The results of this evaluation were used to determine the average cost for detection of one episode of regulatorily significant toxicity.

These 7-day chronic tests are labor intensive and this accounts for most of the cost. MEC Analytical Systems, Inc. in Carlsbad, CA has recently estimated that 20 person-hours are devoted to every 7-day chronic test with fathead minnow or *Ceriodaphnia dubia*. The MEC time estimate is close to that produced by the Oak Ridge National Laboratory in 1988 for the same tests [9].

The mean of the IWCs from the 53 NPDES permittees was determined. This mean was compared to the NOECs from all of the 105 permittees with chronic WET tests in order to estimate a compliance rate that accounted for all data.

RESULTS AND DISCUSSION

The compliance failure rate at the IWC determined from the 53 permittees with a known IWC is 8% of chronic WET tests. The compliance failure rate estimated by comparing NOECs from all 105 permittees to the average IWC is 11% of chronic WET tests. For the purpose of this evaluation, a 10% compliance failure rate represents both of these numbers well. With a toxicity occurring at the IWC 10% of the time, a permittee has a 66% chance of passing all chronic WET tests in a year with quarterly sampling. The same typical permittee has a 28% chance of passing all tests from monthly sampling. It should also be noted that this means that the above compliance failure rates are under-estimated since 90% of the permittees did quarterly sampling and the highest monitoring frequency recorded was monthly.

The following table only addresses the chance of finding effluent toxicity occurring 10% of the time with a random distribution. Detecting effluent toxicity and determining its pattern of occurrence (including duration) over a year would likely require more samples. Exactly how many more could not be determined because quarterly and monthly monitoring provided insufficient data to make an estimation.

The number of chronic WET tests for each of the 53 permittees was multiplied by the average cost estimate of $1,200 in order to estimate the total testing cost for each permittee.

The number of toxicity detections was determined for each permittee by counting failures at the effluent concentration (ACEC) which is used to determine the need for a WET limit at the IWC (CCEC). The ACEC is higher to provide a safety factor and determine the reasonable potential to fail at the CCEC. The ACEC is used for this evaluation because it provides the largest quantification of regulatorily “useful” information and is also toxic whenever the CCEC is toxic if there is a typical concentration-response relationship.

The total chronic testing cost for each permittee was divided by the number of failures at the ACEC. The result is the cost per toxicity detection at meaningful levels. This cost ranged from a low of $1,300/toxicity detection to a high of $40,000/toxicity detection. The average is $11,000/toxicity detection.

CONCLUSION

Common effluent monitoring frequencies are often inadequate for both regulatory and scientific purposes. Episodic effluent toxicity cannot be adequately characterized as to frequency or duration with quarterly or monthly sampling.

One permittee having trouble complying with a chronic WET limit decided to try to prove the *Ceriodaphnia* test to be unreliable. This permittee split samples between two labs for weekly testing in May and June 1995. The testing demonstrated instead that the effluent was toxic at all effluent concentrations down to the IWC of 5% effluent constantly for about 3 weeks. Mortality was sometimes complete at all test concentrations within 24 hours of test initiation. The labs were in exact agreement on the results of these tests. Neither quarterly nor monthly testing could have determined the duration of this toxic episode.

Effluent toxicity disappeared when a TIE was begun. The TIE took longer to complete and was more expensive because the pattern of toxicity was unknown and samples taken over several months for the TIE had little or no toxicity. The TIE eventually found tetramethylammonium hydroxide (TMAH) to be the toxicant and treatment for TMAH is being installed.

The standard WET tests, especially the 7-day chronic WET tests, are relatively expensive. The expense of the tests discourages realistic monitoring frequencies and reduces the cost-effectiveness of toxicity detection.

In order to allow adequate effluent monitoring frequencies and improve the cost-effectiveness and efficiency of the regulation of effluent toxicity, a selection of rapid screening toxicity tests that are quicker and cheaper than standard toxicity tests needs to be established. In one evaluation, Toussaint *et al* compared the response of 5 rapid screening tests to the response of 5 standard acute toxicity tests using 11 chemicals. 3 of the rapid screening tests performed similarly to the standard tests.

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